Arctic Sea Ice Loss also Promotes Weakening of East Asian Winter Monsoon

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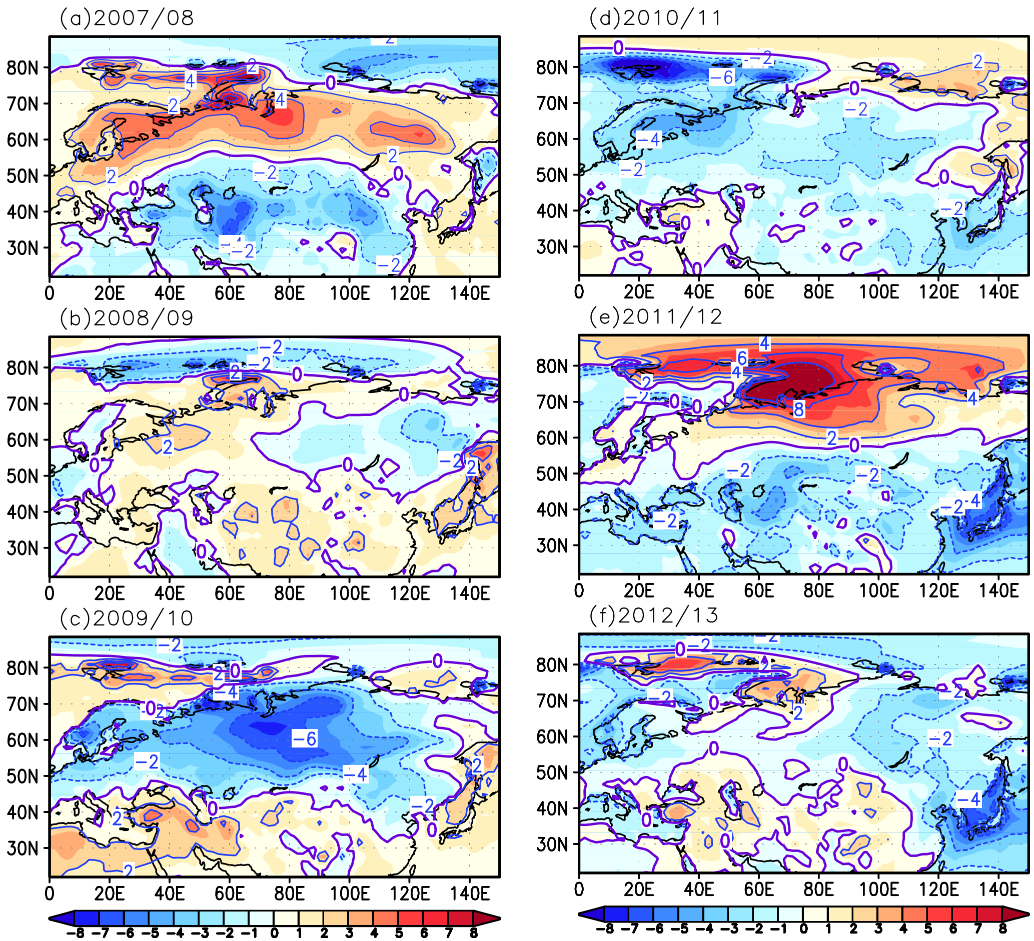
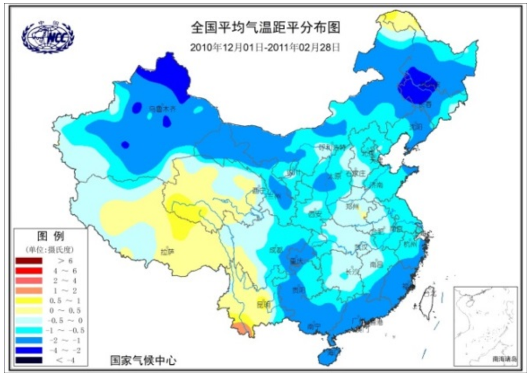
- **Motivations**
- **Two patterns of winter atmospheric variability and their associations with westerly flow over Asia and Arctic**
- **Possible associations with autumn sea ice loss**
- **Conclusion**

Motivations

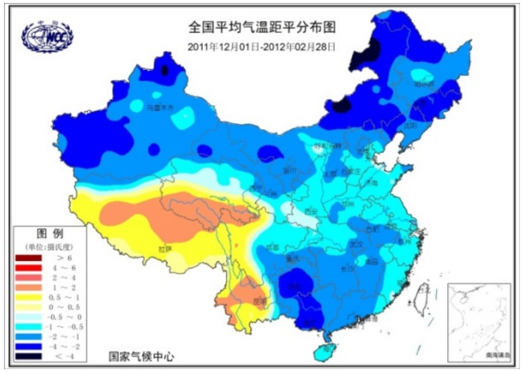
(a) Cold and warm winters alternately occurred



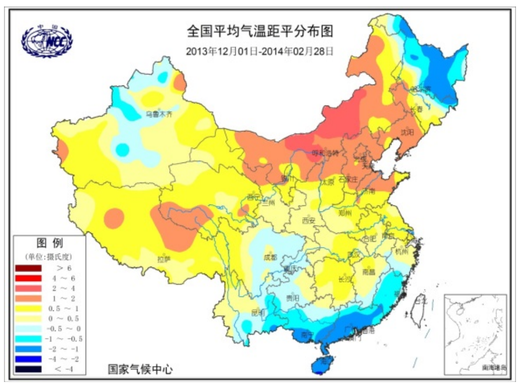
Winter SAT anomalies after detrending over the past 34 winters from 1979 to 2013 (NCEP/NCAR re-analysis data I).



2010/11

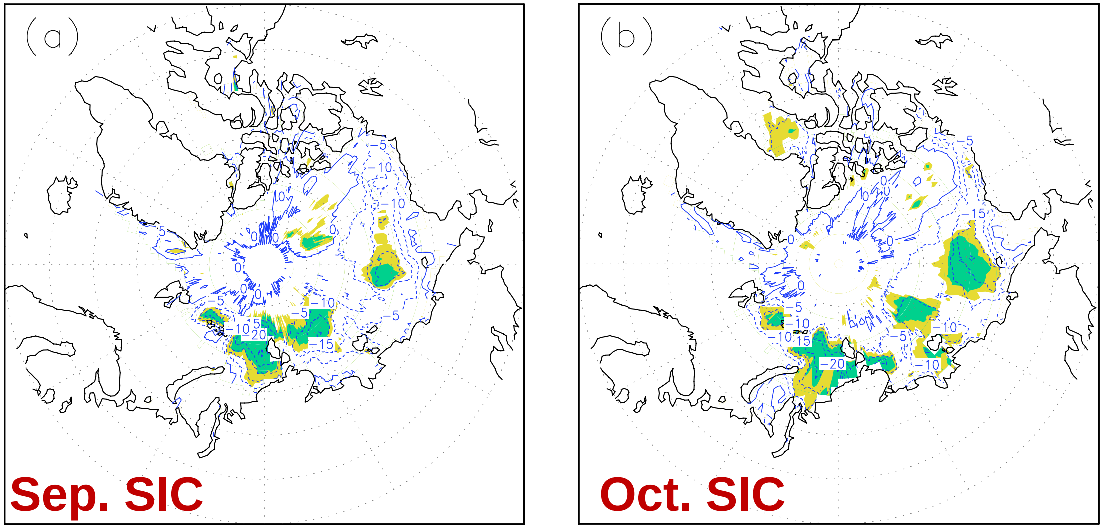


2011/12

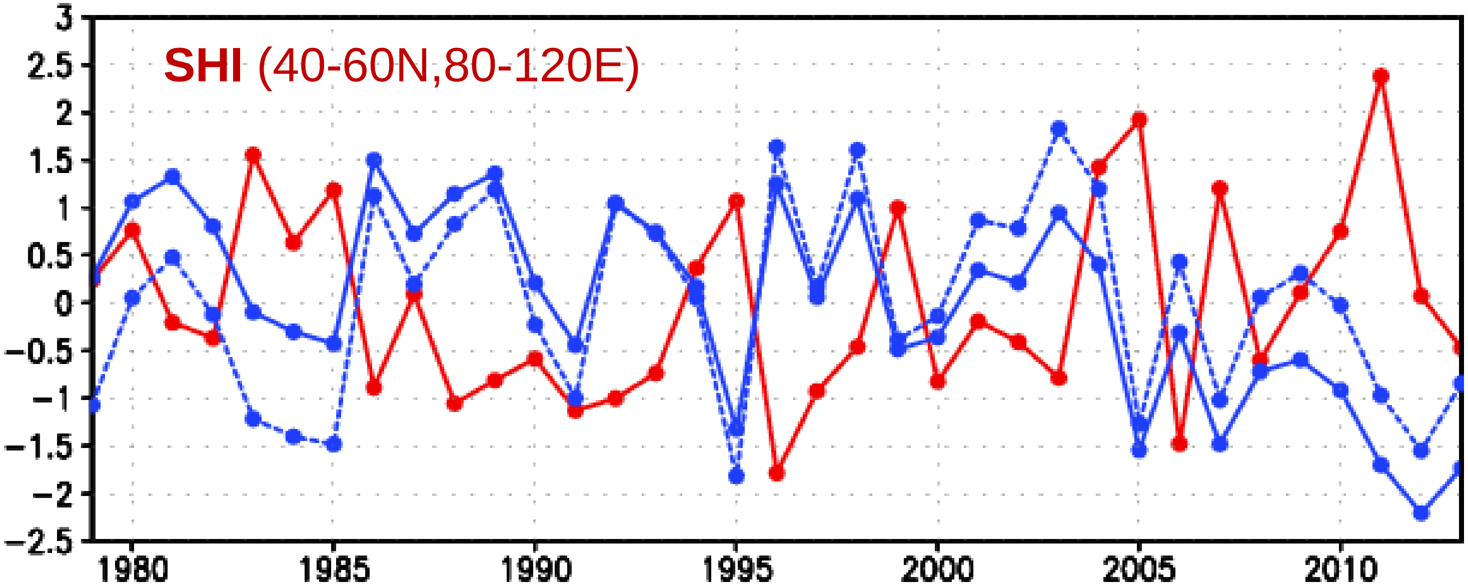


2013/14

(b) SH experienced rapidly changes



Francis et al. 2009, Honda et al. 2009, Chinese Science Bulletin, 2011

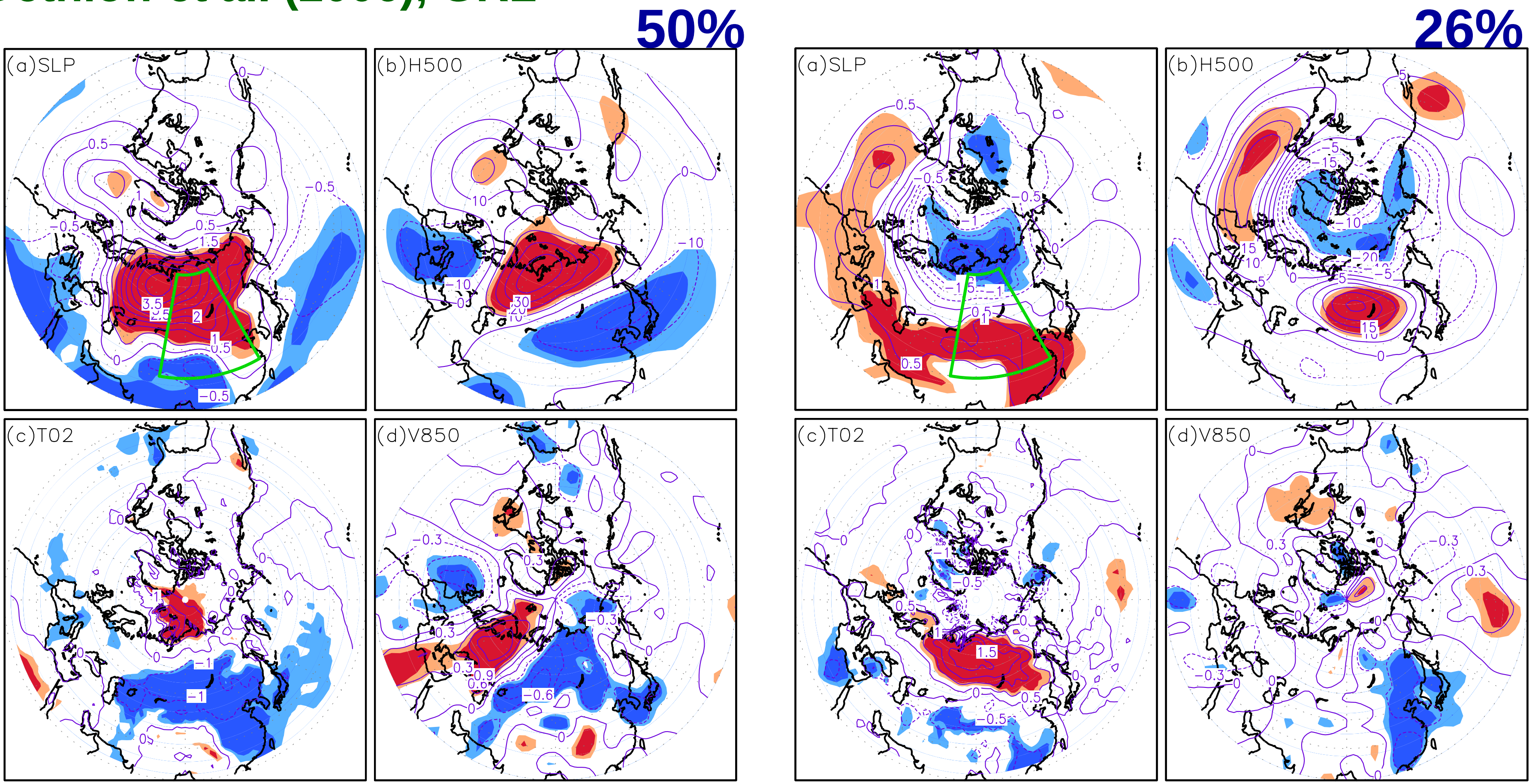


Winter SHI (red line) and September SIC (60.5-149.5E and 76.5-83.5N)

Two patterns of winter atmospheric variability and their associations with westerly flow over Asia and Arctic

Jung et al. (2014), GRL (Fig. 3)

Dethloff et al. (2006), GRL

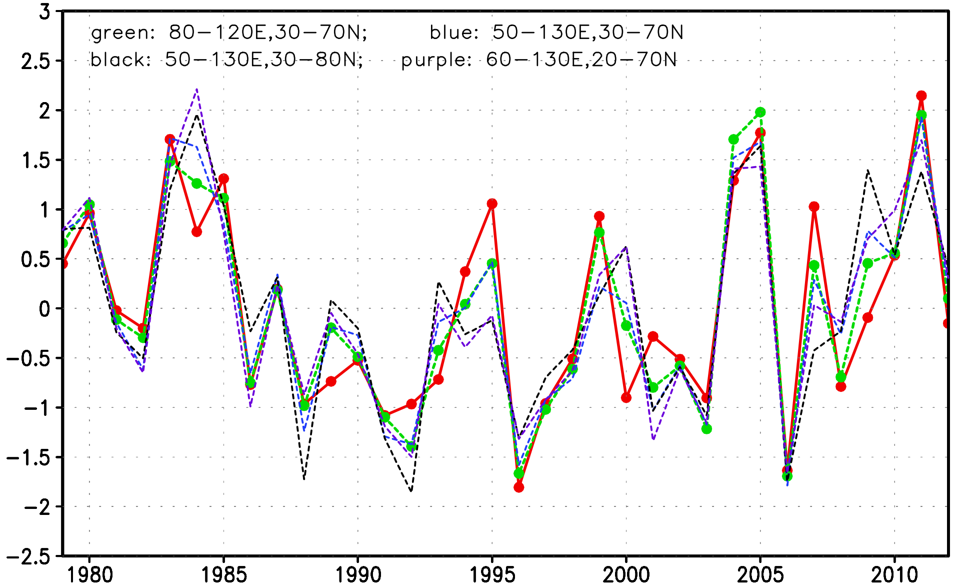


80-120E, 30-70N

Siberian high (SH) pattern

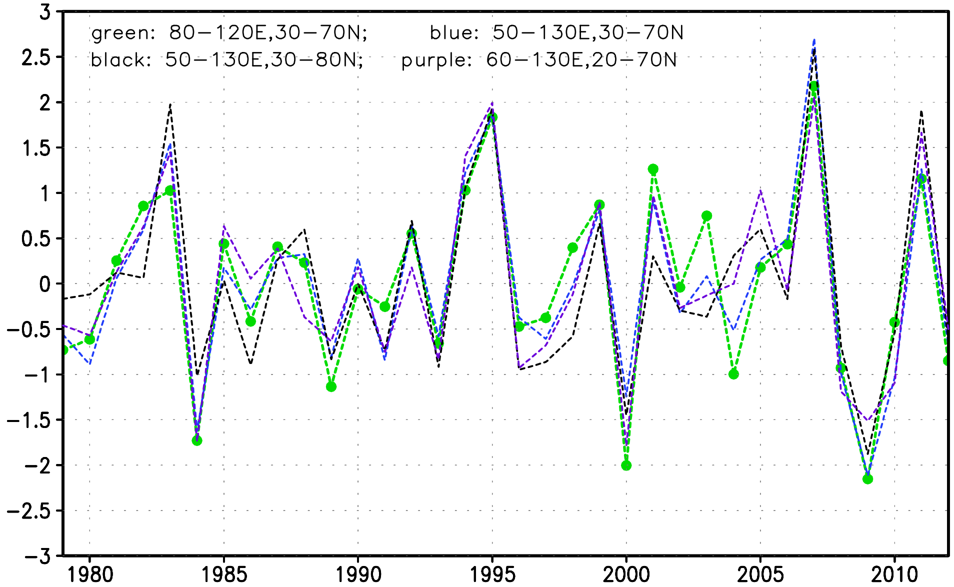
Asia-Arctic (AA) pattern

SH pattern

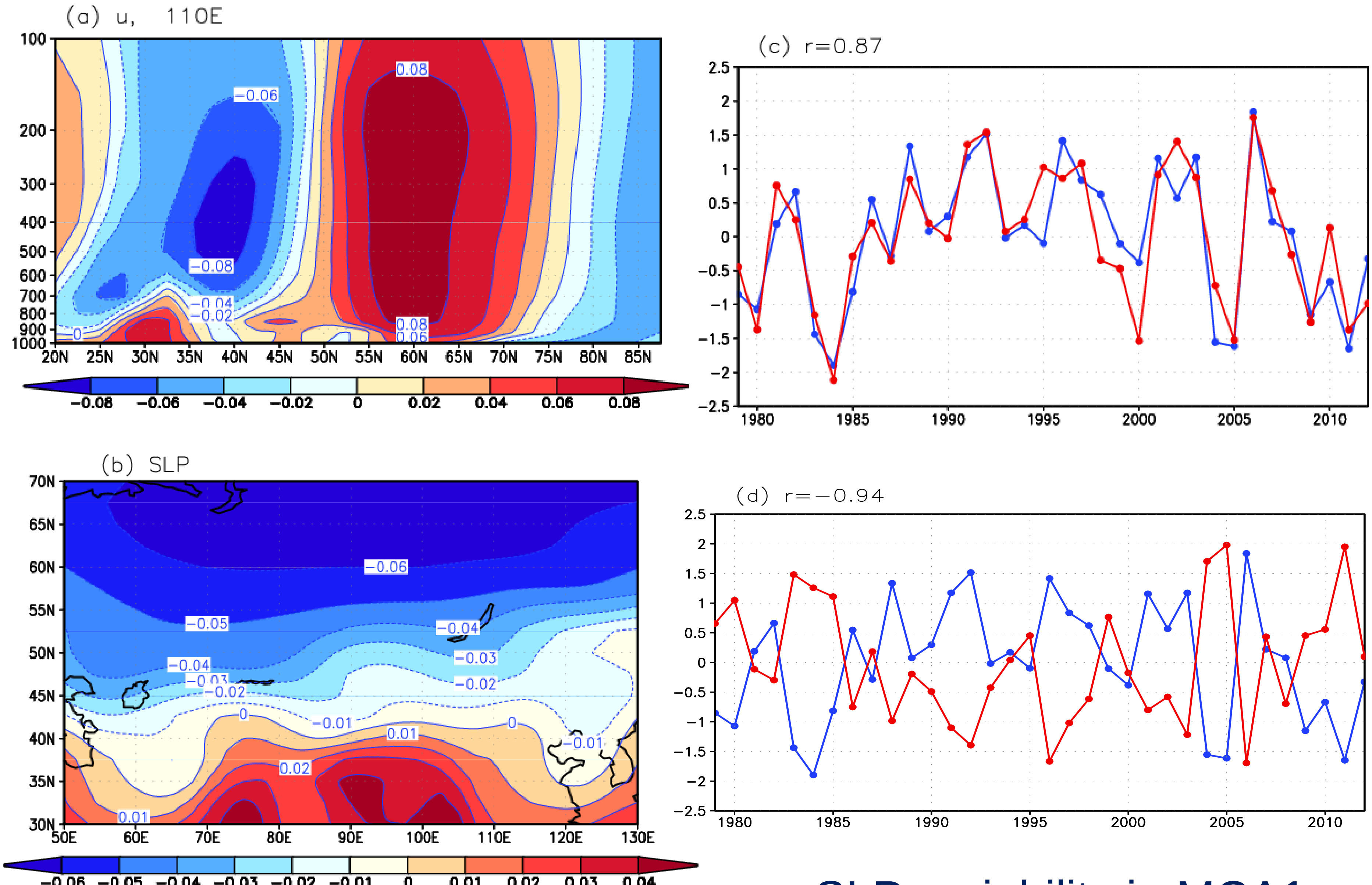


0.95, 80-120E,30-70N
0.90, 50-130E,30-70N
0.75, 50-130E,30-80N
0.81 60-130E,20-70N

AA pattern



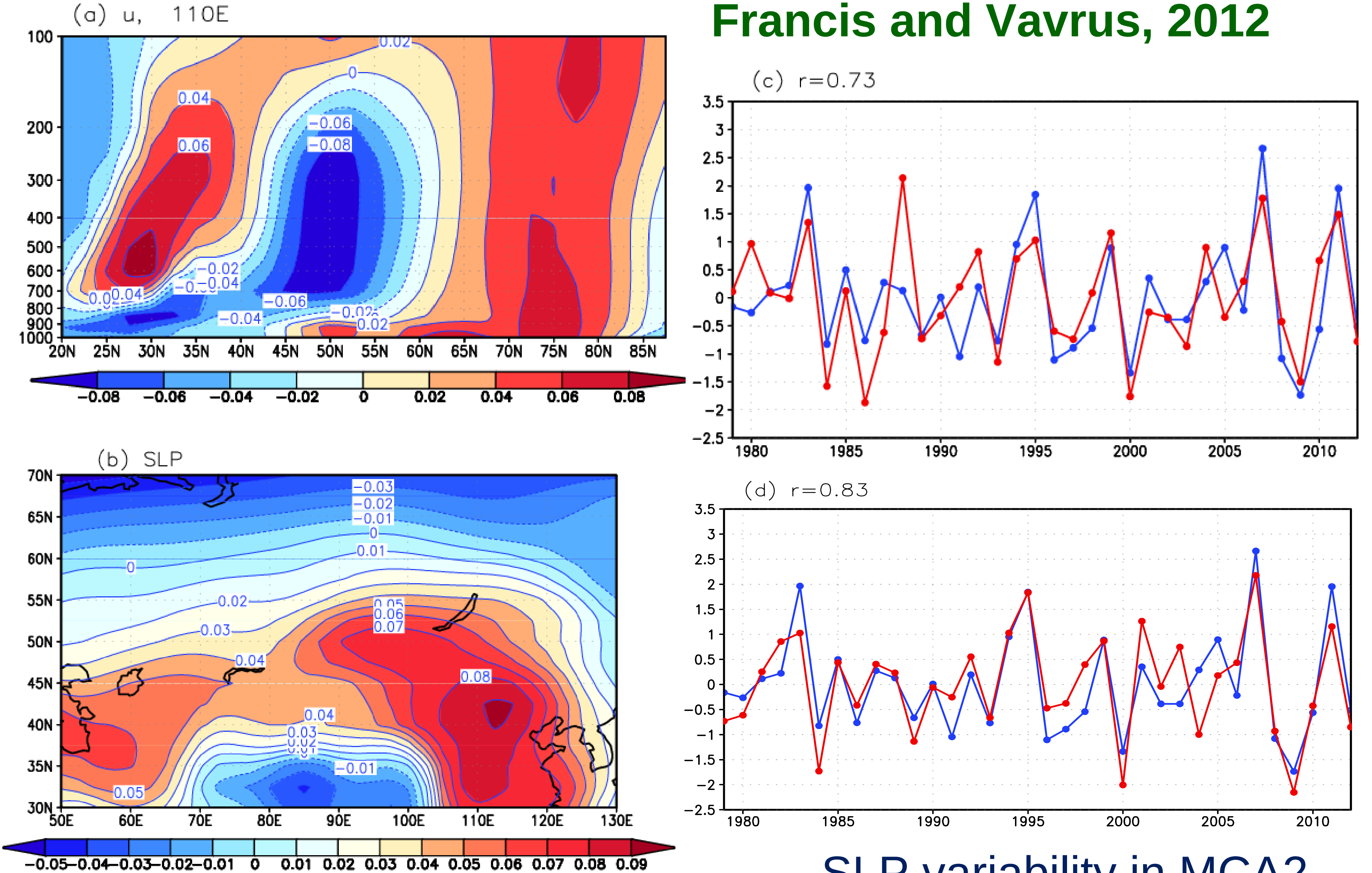
-0.95,
0.84,
-0.90



MCA1, 71%

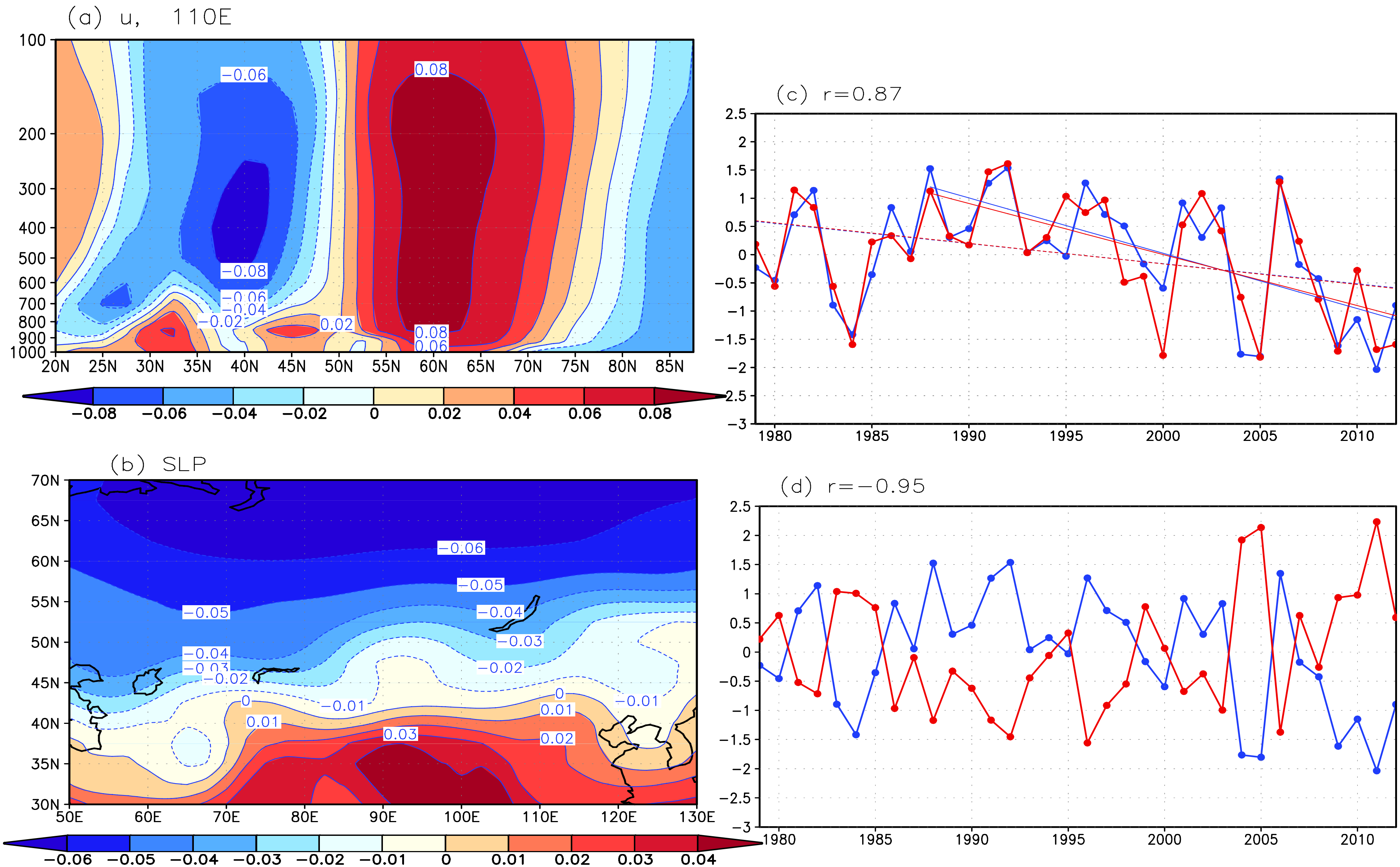
SLP variability in MCA1 and the SH pattern

Francis and Vavrus, 2012



MCA2, 18%

SLP variability in MCA2 and the AA pattern



MCA1, 74%

Table 1. Winter cases with their standard deviations >0.8 or <-0.8

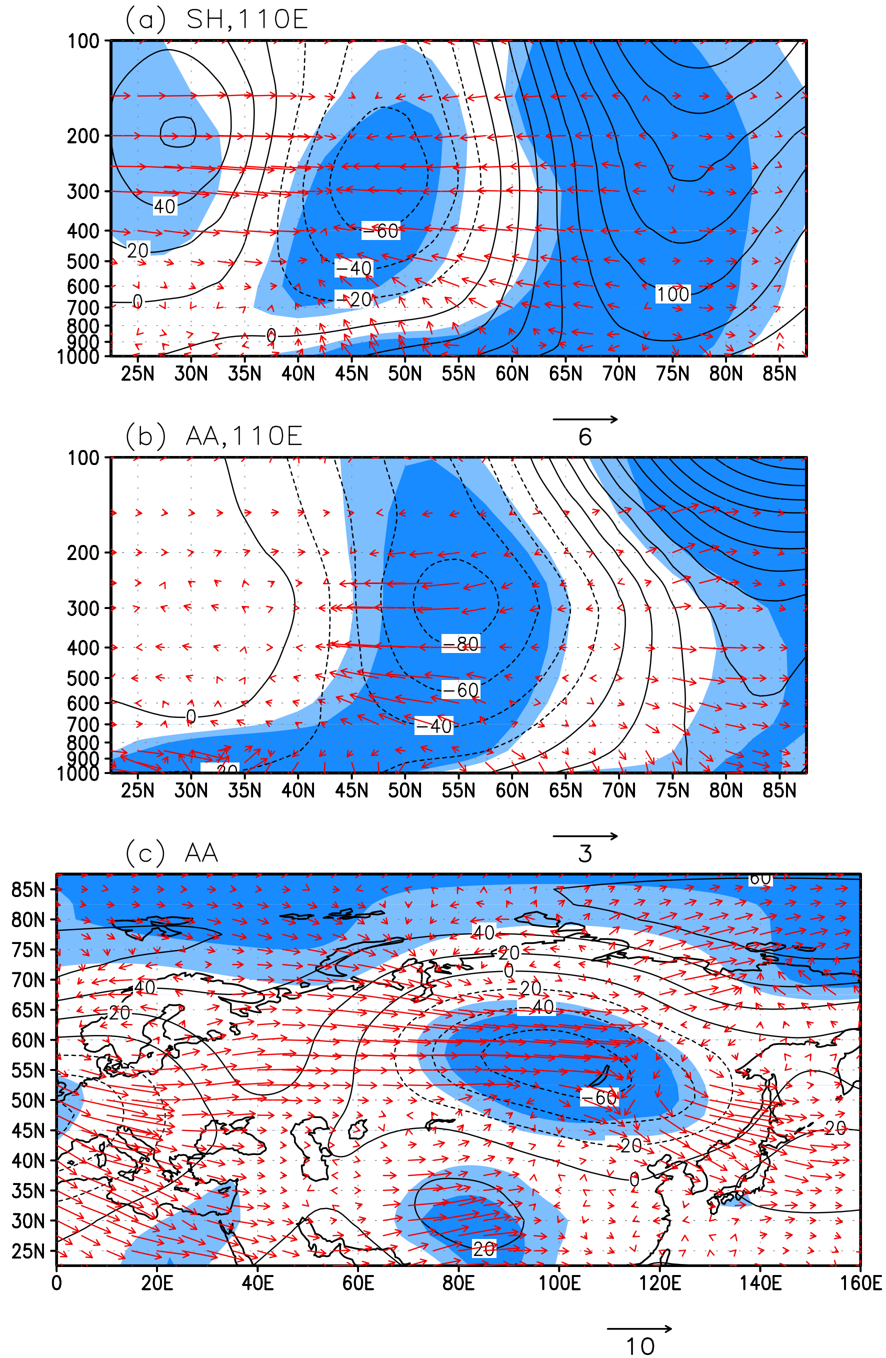
	Positive Phase	Negative phase
SH pattern	*1980/81*, **1983/84, 1984/85**, *1985/86*, **2004/05,** *2005/06*, **2011/12**	*1988/89*, *1991/92*, *1992/93*, *1996/97*, *1997/98*, *2003/04*, *2006/07*
AA pattern	*1982/83*, **1983/84**, *1994/95*, *1995/96*, *1999/2000*, *2001/02*, *2007/08*, **2011/12**	**1984/85**, *1989/90*, *2000/01*, **2004/05**, *2008/09*, *2009/10*, *2012/13*

Bolds: the common winters in both of SH and AA patterns

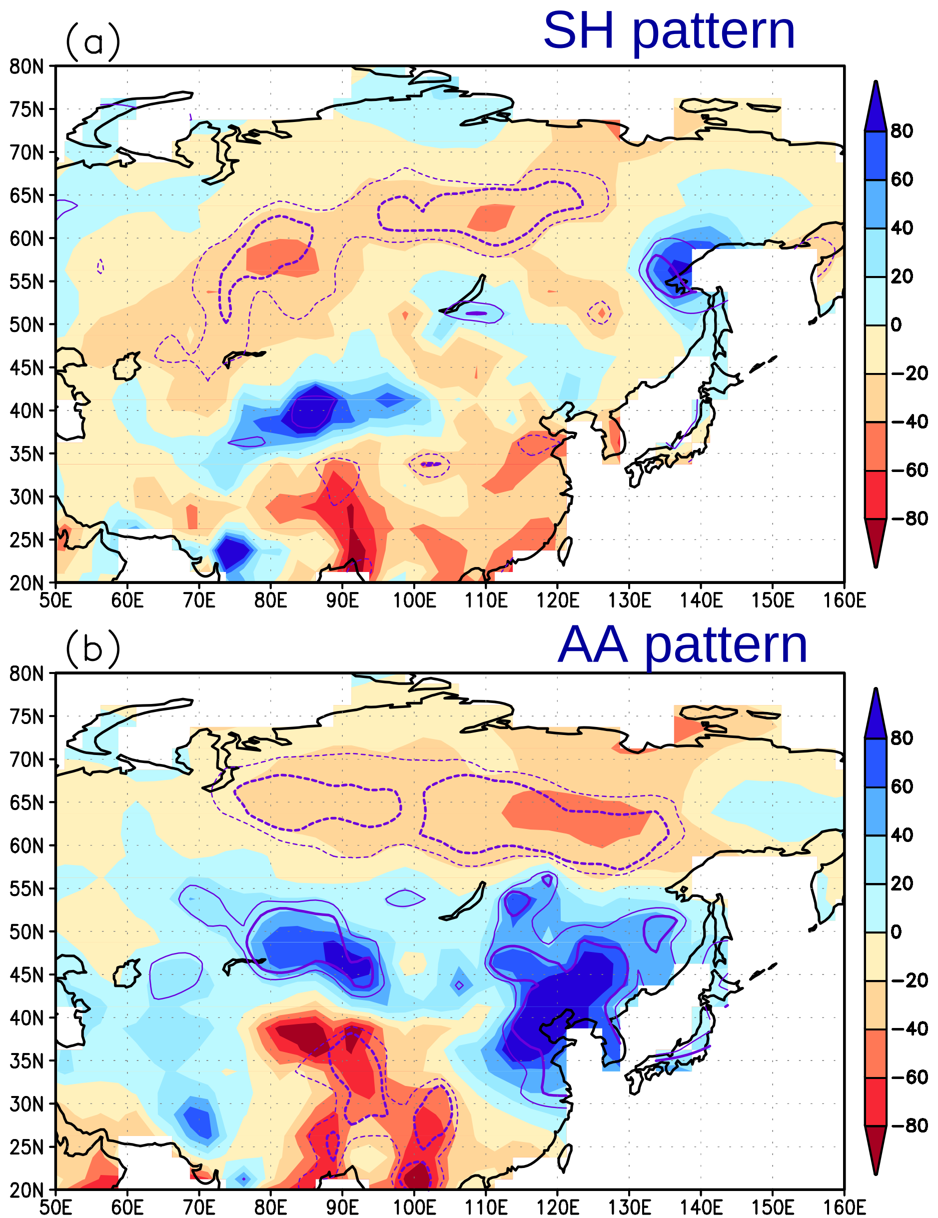
2007/08—2012/13 (6 winters, autumn sea ice kept their low extents)

AA: 2007/08, 2008/09, 2009/10, 2011/12, 2012/13

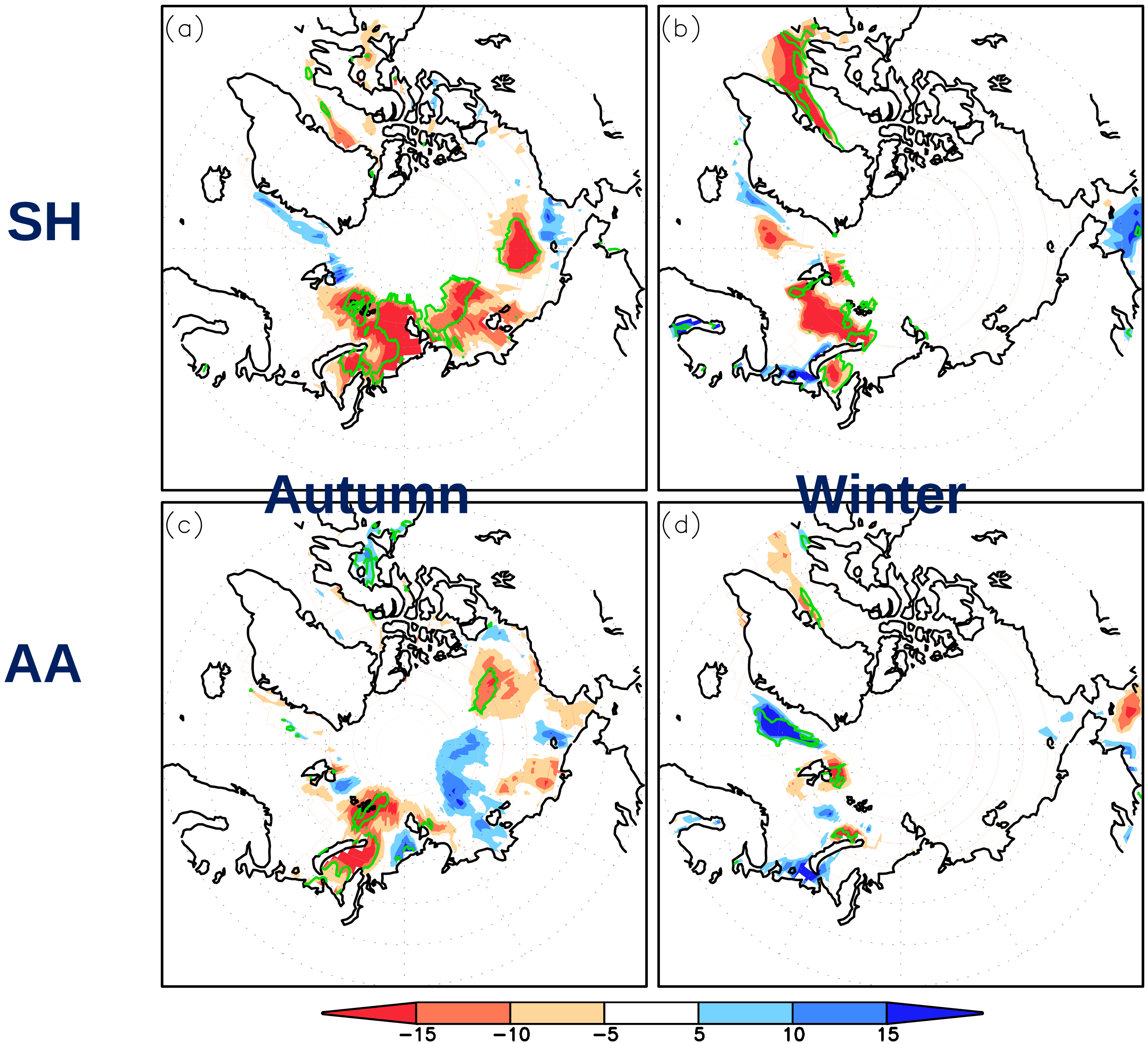
SH: 2011/12



(a) SH,110E
100
200
300
400
500
600
700
800
900
1000
25N 30N 35N 40N 45N 50N 55N 60N 65N 70N 75N 80N 85N
40
20
0
-60
-40
-20
100
(b) AA,110E
6
-80
-60
-40
0
(c) AA
3
85N 80N 75N 70N 65N 60N 55N 50N 45N 40N 35N 30N 25N
0 20E 40E 60E 80E 100E 120E 140E 160E
60
40
20
0
-20
-40
-60
10



Anomalous winter precipitation percentages, thin (dashed thin) and thick (dashed thick) purple contours indicate positive (negative) precipitation differences exceeding 0.05 and 0.01 significance levels, respectively


SH
AA
(a)
(b)
(c)
(d)
Autumn
Winter
−15
−10
−5
5
10
15

- ECHAM5 model (T63 and 19 pressure levels) was applied to explore the impacts of SIC on the model atmosphere.

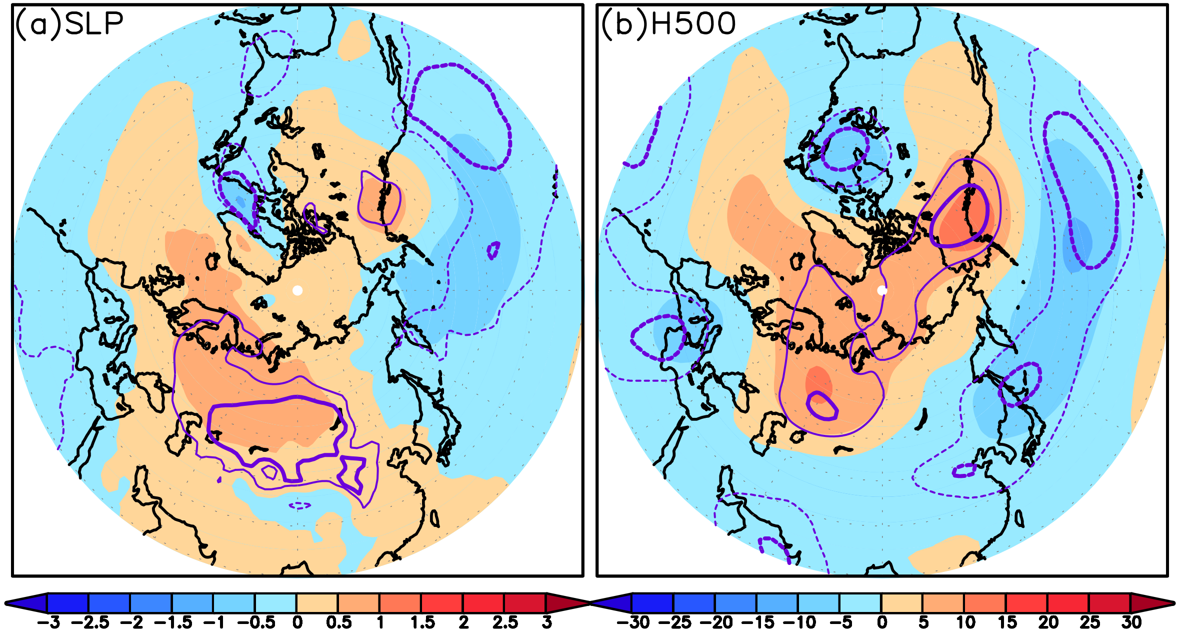
- Simulations were performed using climatological global monthly SST, climatological southern hemisphere monthly SIC and observed northern hemisphere monthly SIC from January 1978 to November 2012 as the external forcing, and this experiment was repeated with 40 different atmospheric initial conditions that were derived from a 50-year control run.

- In simulation experiments, climatological SSTs were used to replace the melted SIC, unlike in Screen et al. (2013, **Climate Dynamics**).

Warm Arctic and Cold Continents

Overland et al. 2010**, Polar Research**

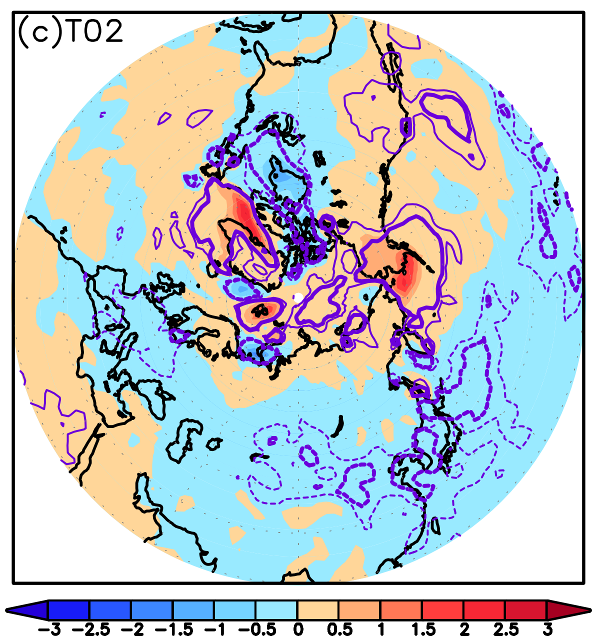
The response is very weak



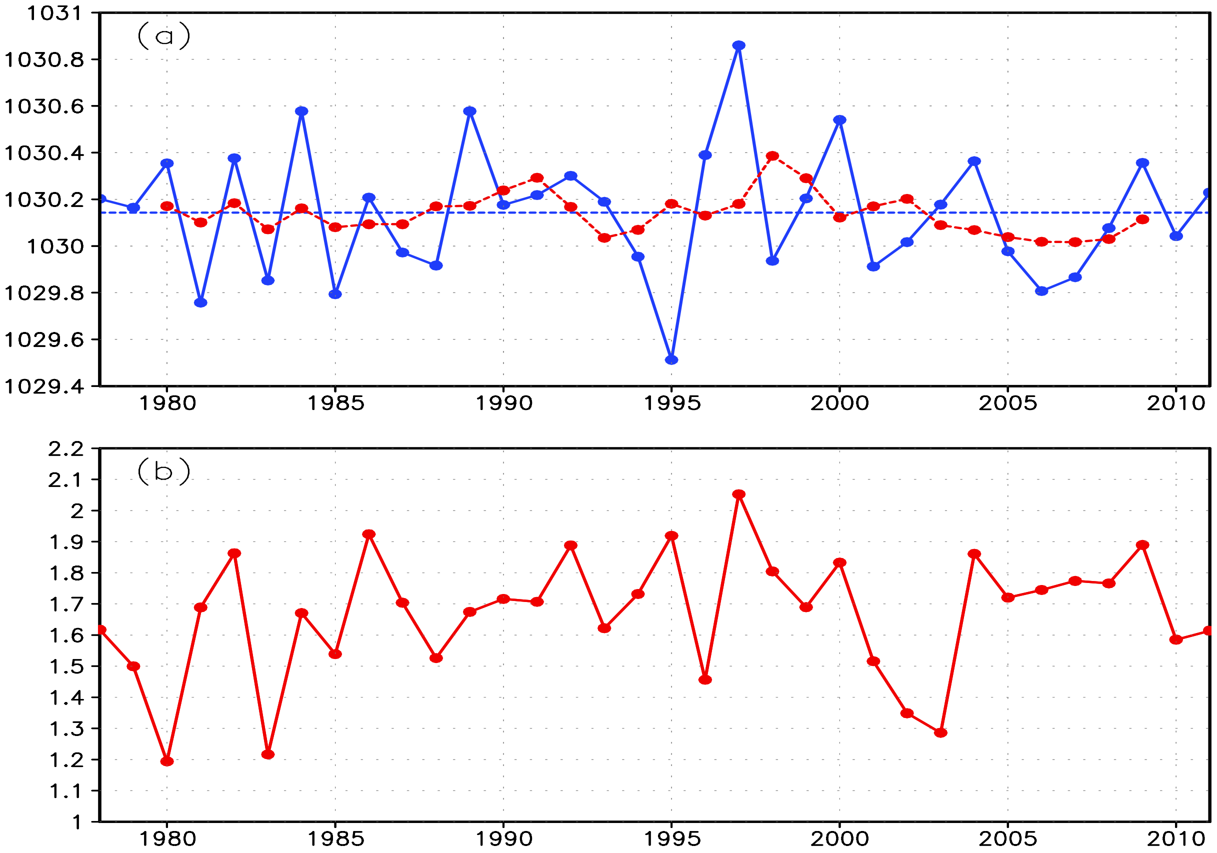
10~15 gpm

Simulated differences between negative and positive phases of the AA pattern ,

1~1.5 hPa



derived from all (40) experiments, thus negative and positive phases contain 240 and 320 winters, respectively



a very narrow range of 1029~1031 hPa

the observed SHI range was 1026.8~1033.5 hPa from 1979 to 2013

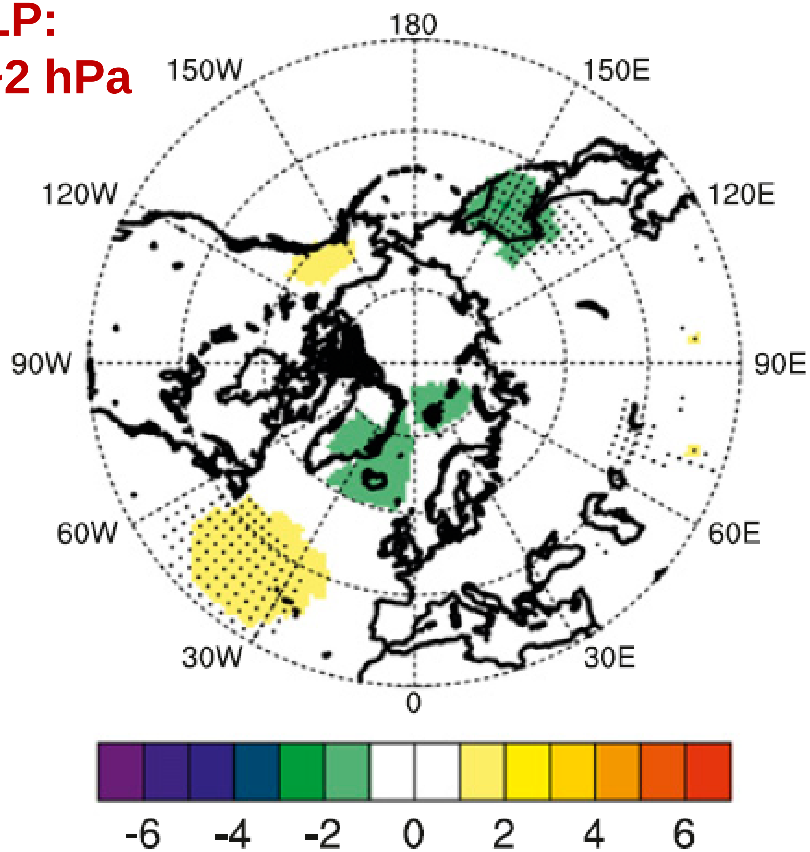
(a) Time series of the simulated winter SHI averaged over 40 experiments, (b) the standard deviation time series of the simulated winter SHI derived from 40 experiments

SLP and height responses are hard to detect them and may be partially or totally masked by atmospheric internal variability (Screen et al. 2013, **Climate Dynamics**).

Peings and Magnusdottir, 2014, **J. Climate**

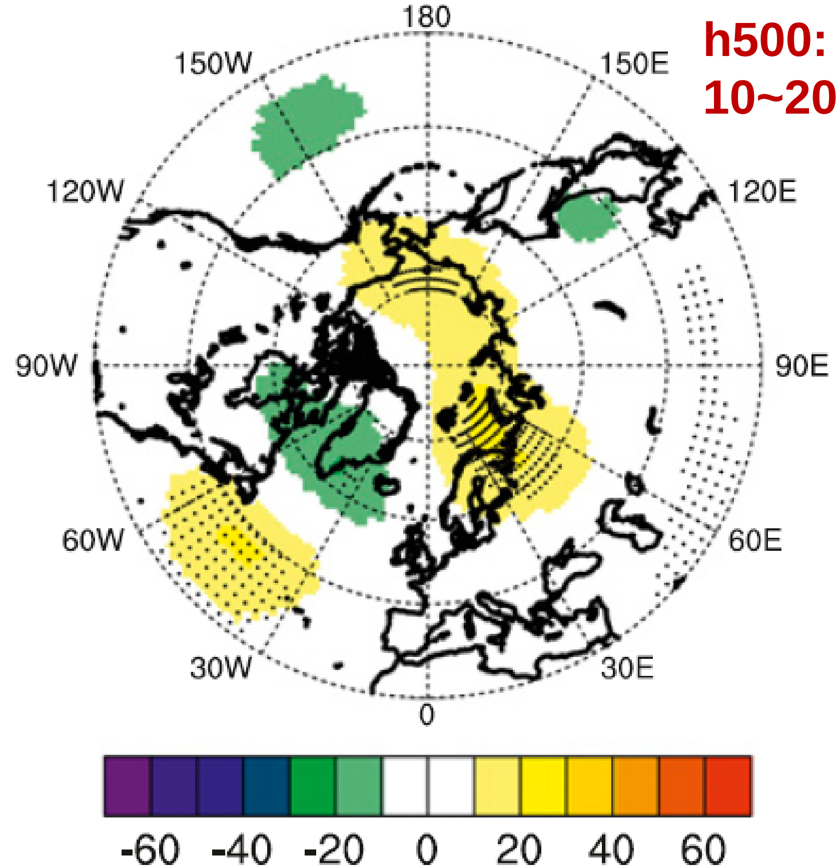
b) 2010C-CTL

SLP:
1~2 hPa



e) 2010C-CTL

h500:
10~20 gpm

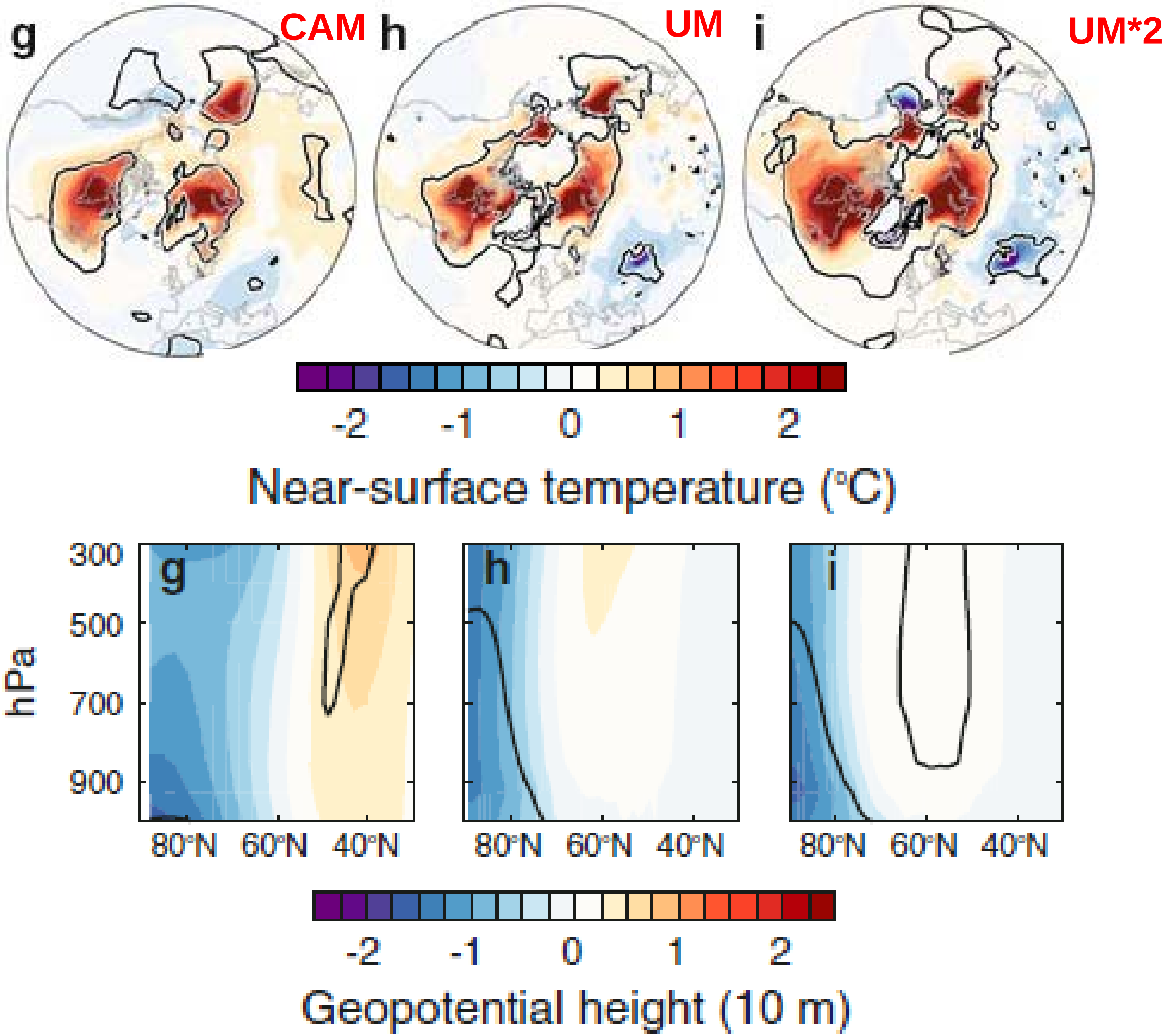


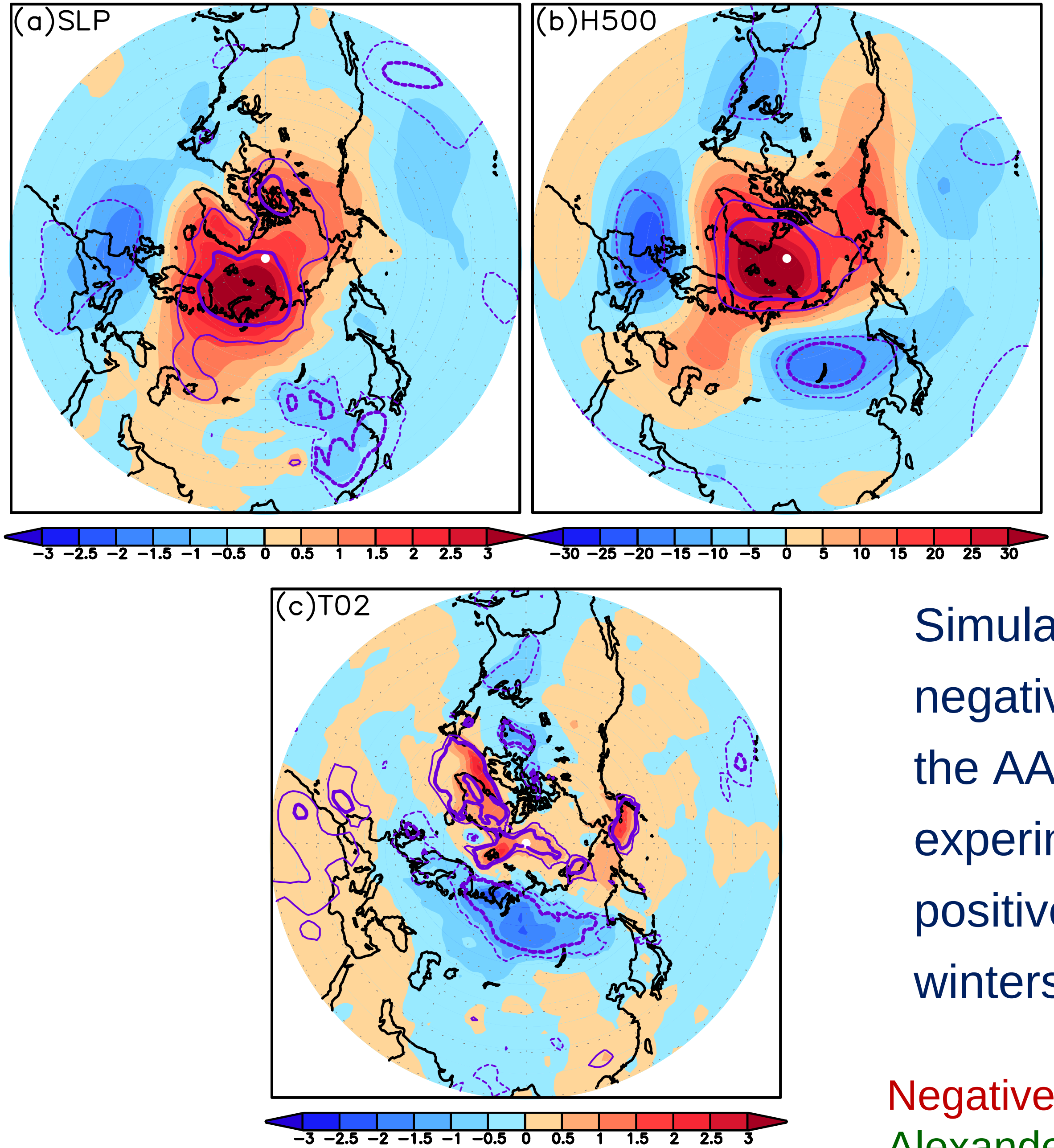
SIC forcing: 2007-2012,
SST forcing considered as in Screen et al. 2013

Screen et al. 2013, **Climate Dynamics**

Winter SAT anomalies

Winter potential hight anomalies





quasi-barotropic structure, differing from Screen et al.(2013) and Peings and Magnusdottir (2014) where baroclinic is evident

Simulated differences between negative and positive phases of the AA pattern, derived from 7 experiments, thus negative and positive phases contain 42 and 56 winters, respectively

Negative feedback mechanism:
Alexander et al., 2004; Deser et al., 2004, 2007; Magnusdottir et al., 2004

Alexander et al. 2004, J. Climate

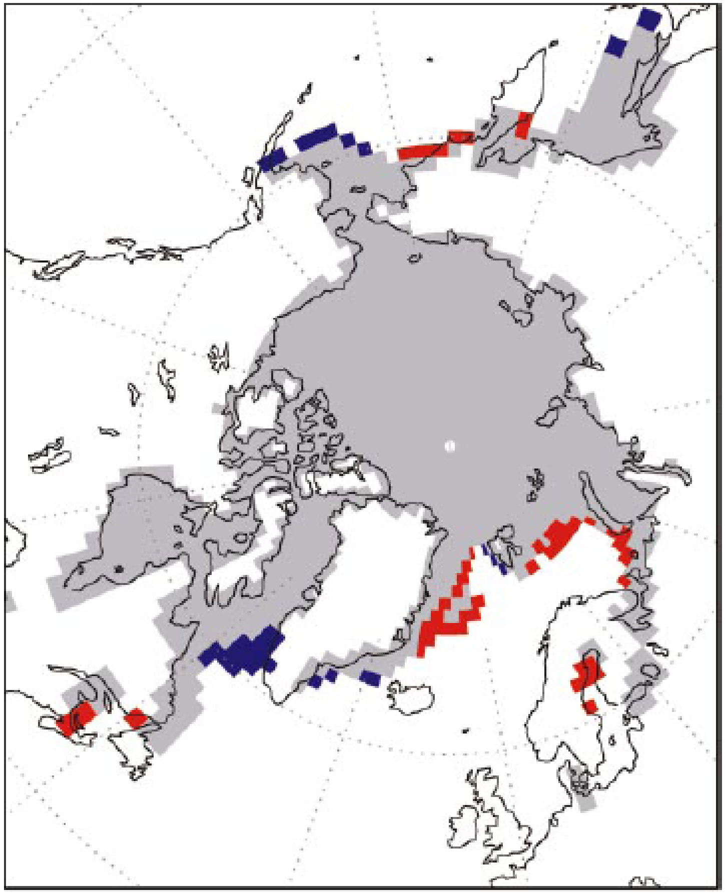
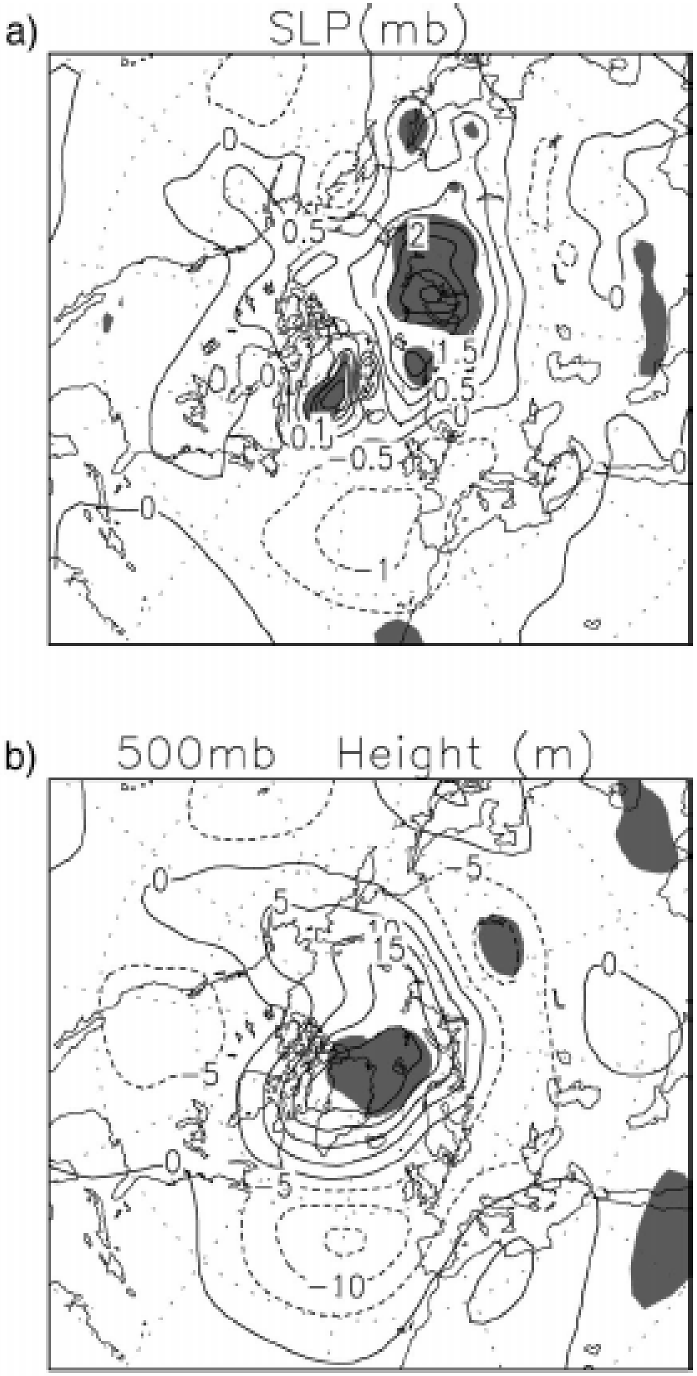
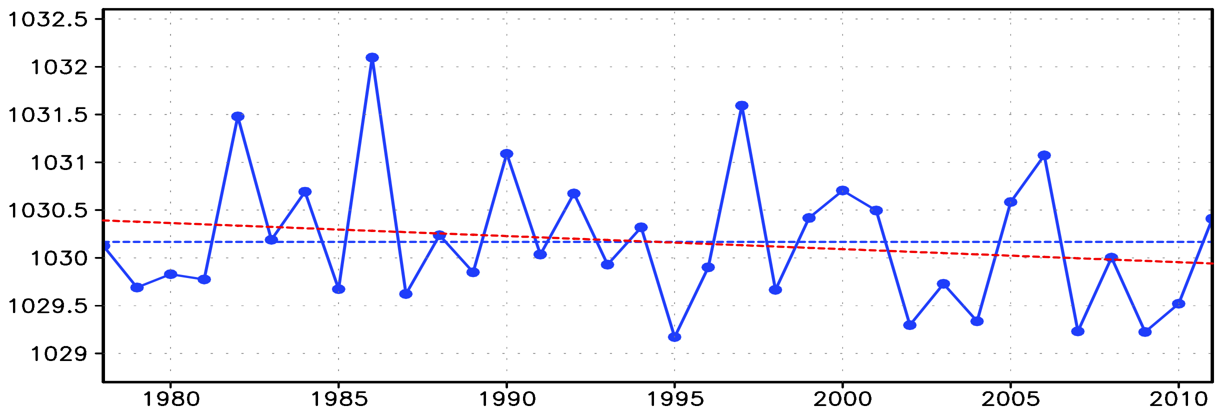
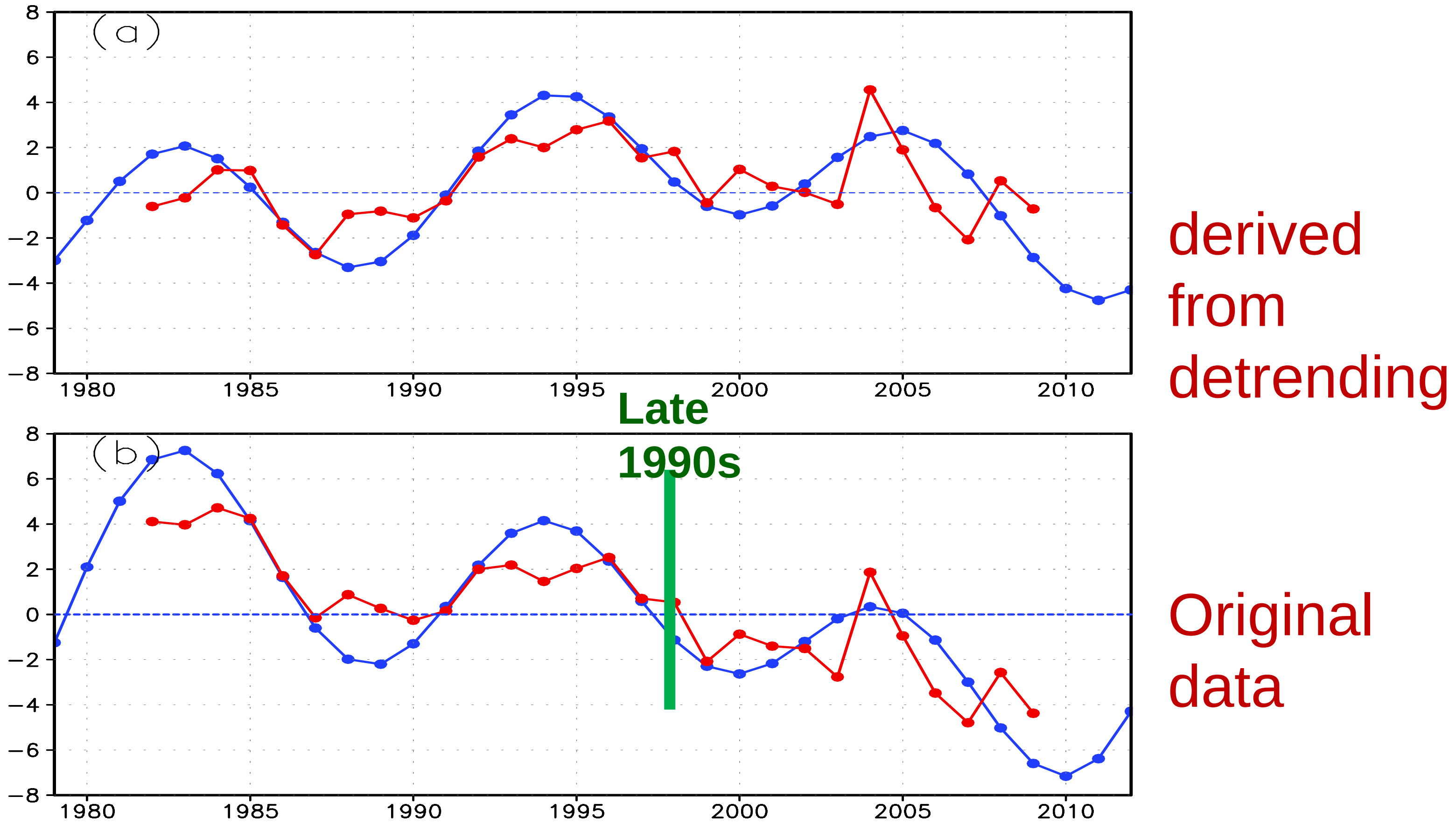


FIG. 2. Sea ice boundary conditions during Jan 1983 in the winter 1982/83 extent (Win83e) experiment. Gray indicates areas with climatological sea ice and blue (red) indicates grid squares where the ice edge has expanded (retreated) relative to climatology. Thus, the gray plus blue areas indicate the full ice extent in the Win83e experiment. Grid squares are set to be ice covered when the ice concentration exceeds 15%.



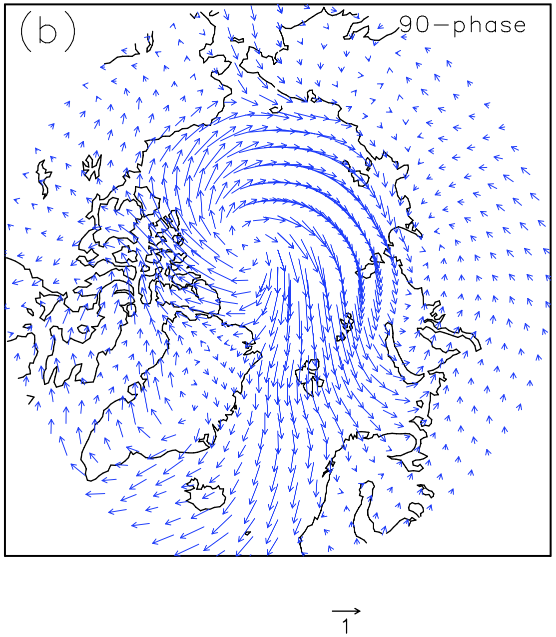


Simulated time series of winter SHI (hPa), averaged over 7 experiments, dashed blue (red) line denote winter mean (trend) of SHI.

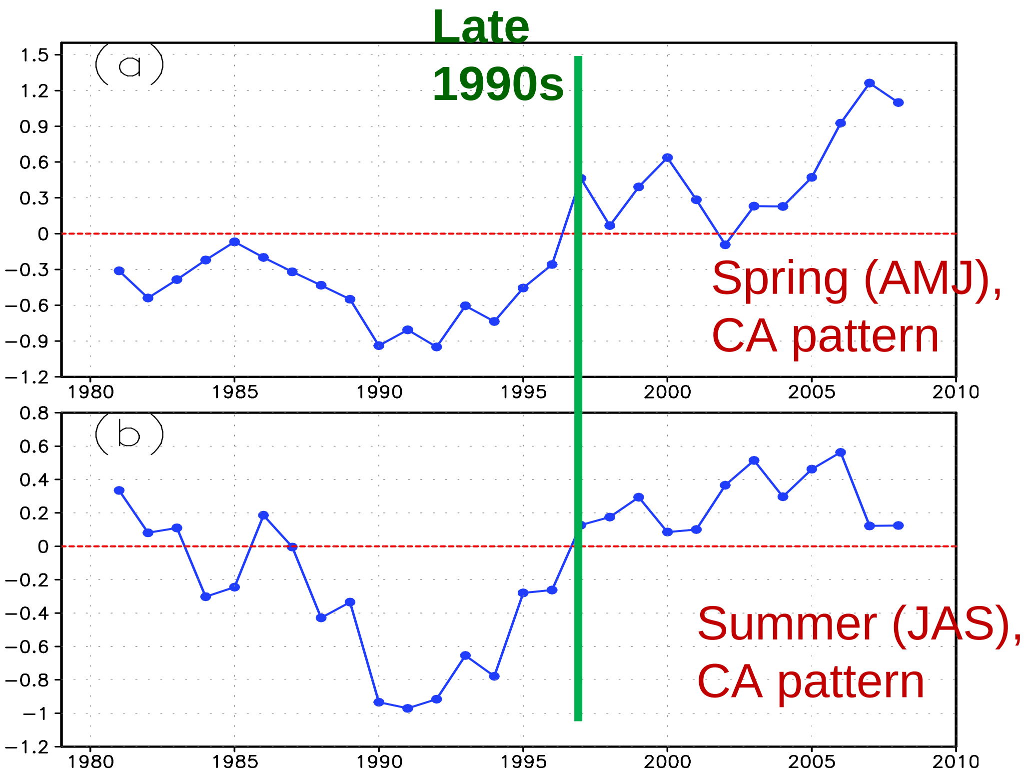


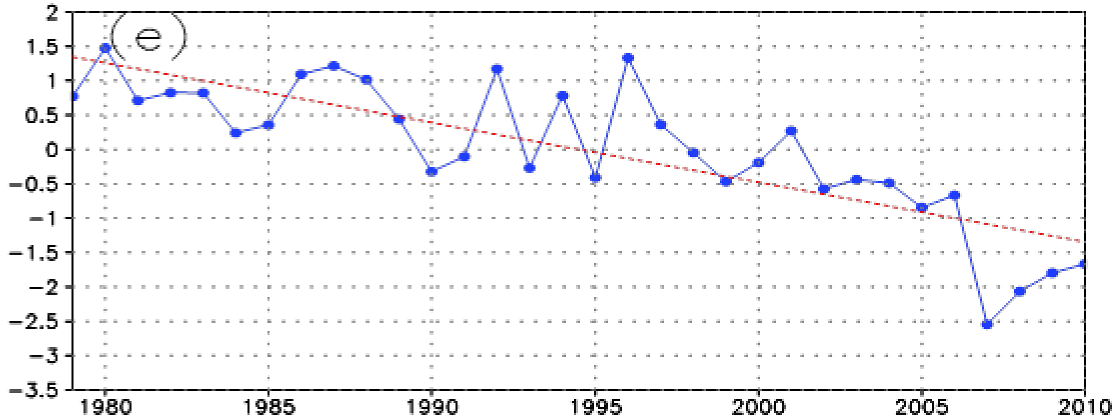
(a) The low-frequency oscillation (＞11 years) time series of the AA pattern (blue line), derived from a harmonic analysis, and the red line is a 7-yr running mean time series of the AA pattern,

(b) as in (a), but the AA pattern was derived from the original winter mean SLP data



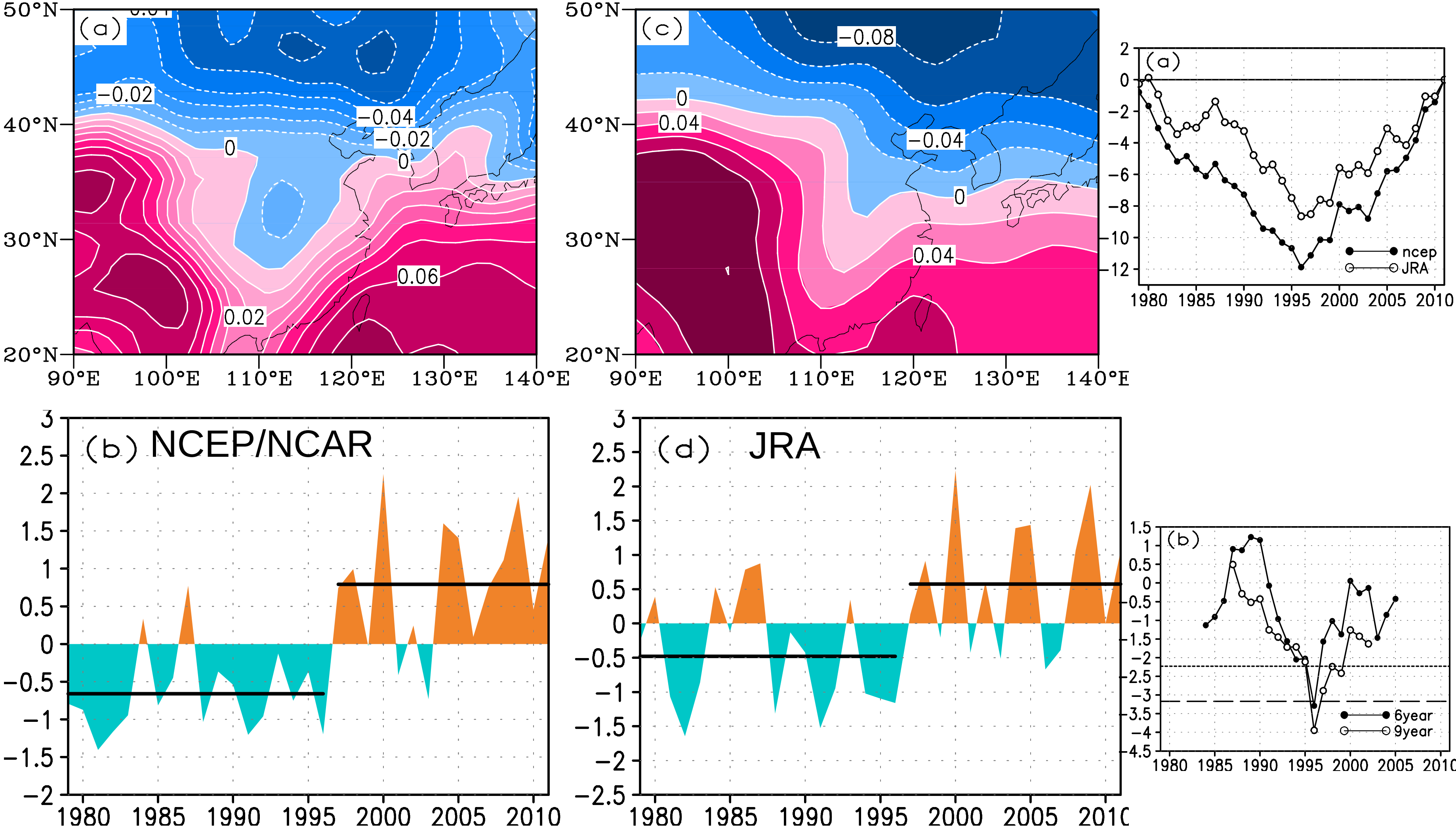
Summer (JAS) Arctic surface wind pattern (CA pattern)





Sep. sea ice extent

Tellus, 2012



Winter SAT in East Asia experienced a decadal shift in the late 1990s, characterized by EOF2

Chinese Science Bulletin, 2013

Conclusions

- the Siberian high (SH) pattern and the Asia-Arctic (AA) pattern.
- The AA pattern plays more important roles in regulating winter precipitation and the 850 hPa meridional wind component over East Asia than the SH pattern, which controls surface air temperature variability over East Asia.

- In the Arctic Ocean and its marginal seas, sea ice loss in both autumn and winter may favor either the positive phase of the SH pattern (or enhanced SH) or the negative phase of the AA pattern.

- The latter corresponds to a weakened East Asian winter monsoon (EAWM) and enhanced winter precipitation in the mid-latitudes of the Asian continent and East Asia.

- The results also imply that the relationship between Arctic sea ice loss and winter atmospheric variability over East Asia is unstable, which is a challenge for predicting the EAWM based on Arctic sea ice loss.

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